Assessing watershed-scale consequences of coal surface mines in the headwaters of the Oldman River Watershed (ORW)

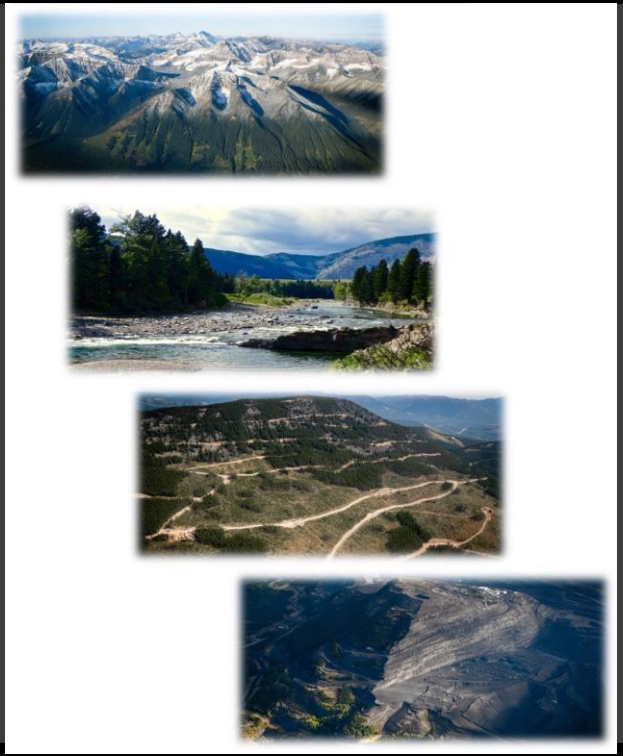
Prepared for

Alberta Coal Policy Committee

Prepared by

Brad Stelfox, Alces Group

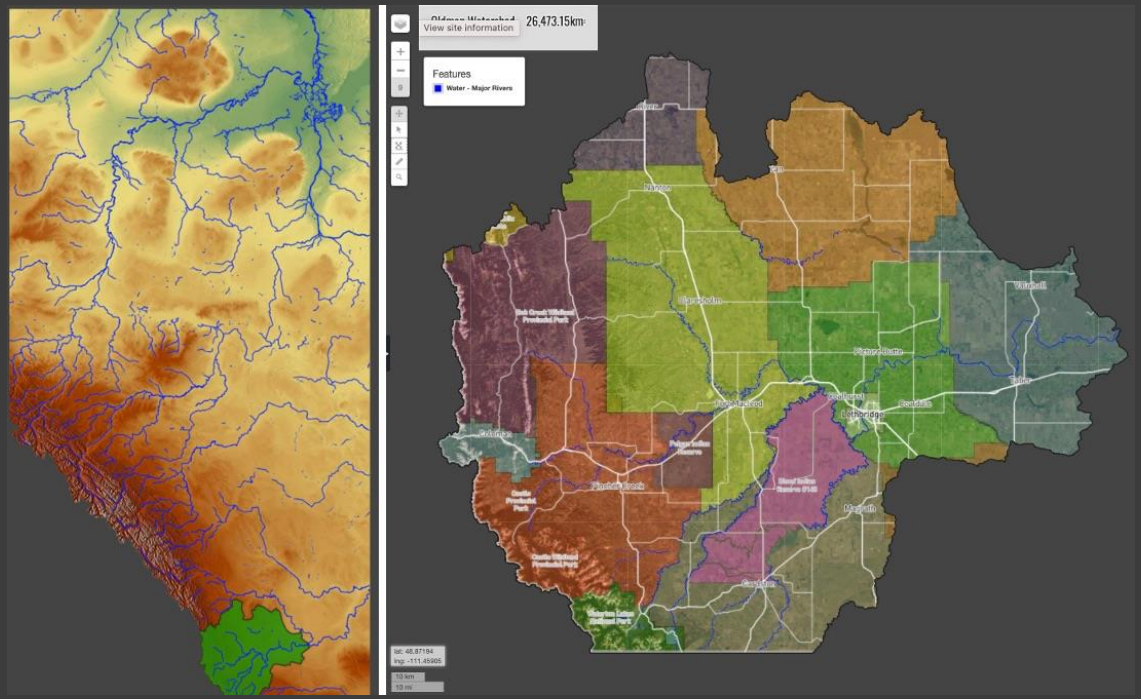
On behalf of the Livingstone Landowners Groups



Dr. Brad Stelfox is a landscape ecologist with the Alces Group who has worked on a wide range of land use issues in Canada and internationally. He is a systems dynamist with a specialty in cumulative effects of land use.

Dr. Bill Donahue has a long career examining the dynamics between land use and water quality. For the period 2015 to 2019, Dr. Donahue worked for the Government of Alberta as Alberta's Chief Monitoring Officer, the Executive Director of both Monitoring and Science in Alberta Environment and Parks, and as a Visiting Scientist in the University of Alberta's Faculty of Science. Since February, he has begun to analyse Alberta Environment's water quality data from monitoring performed between the late 1990s and 2016 both upstream and downstream of the Luscar, Gregg River, and Cheviot coal mines south of Hinton.

The Study Area - Oldman River Watershed



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Placing the Oldman Watershed into Perspective

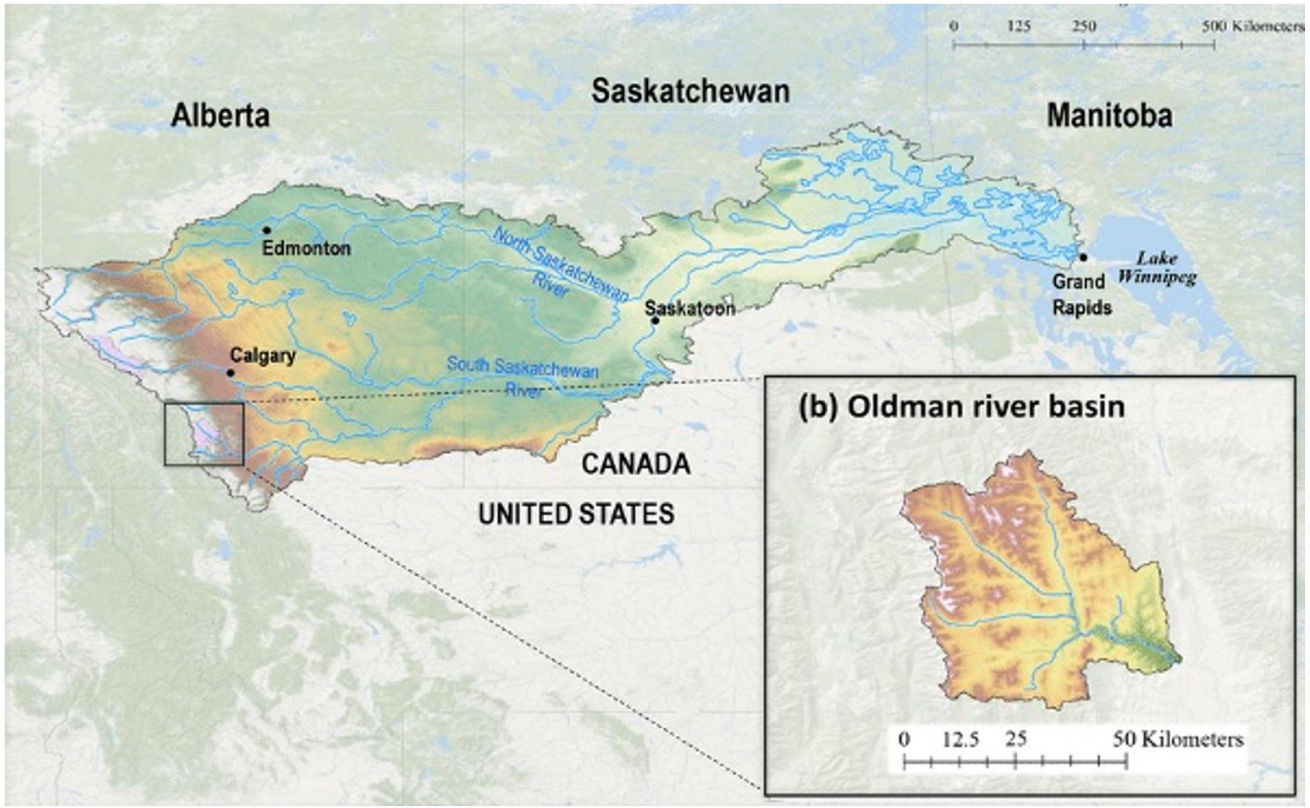
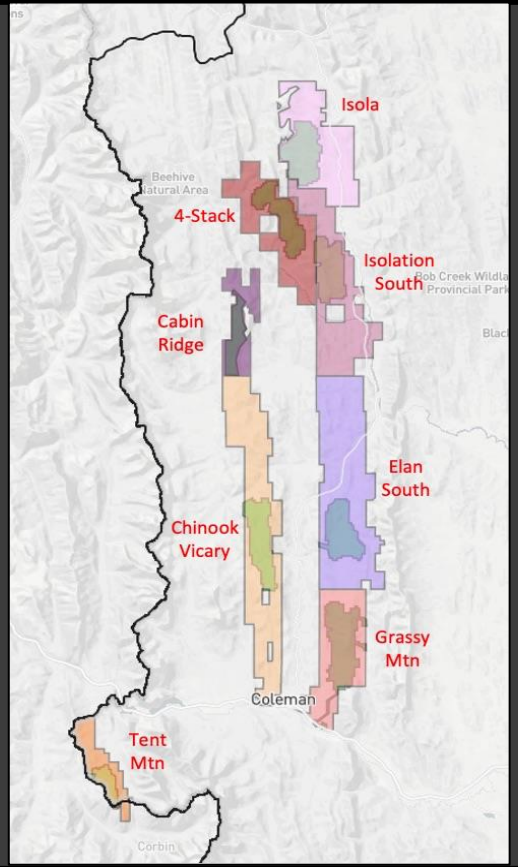
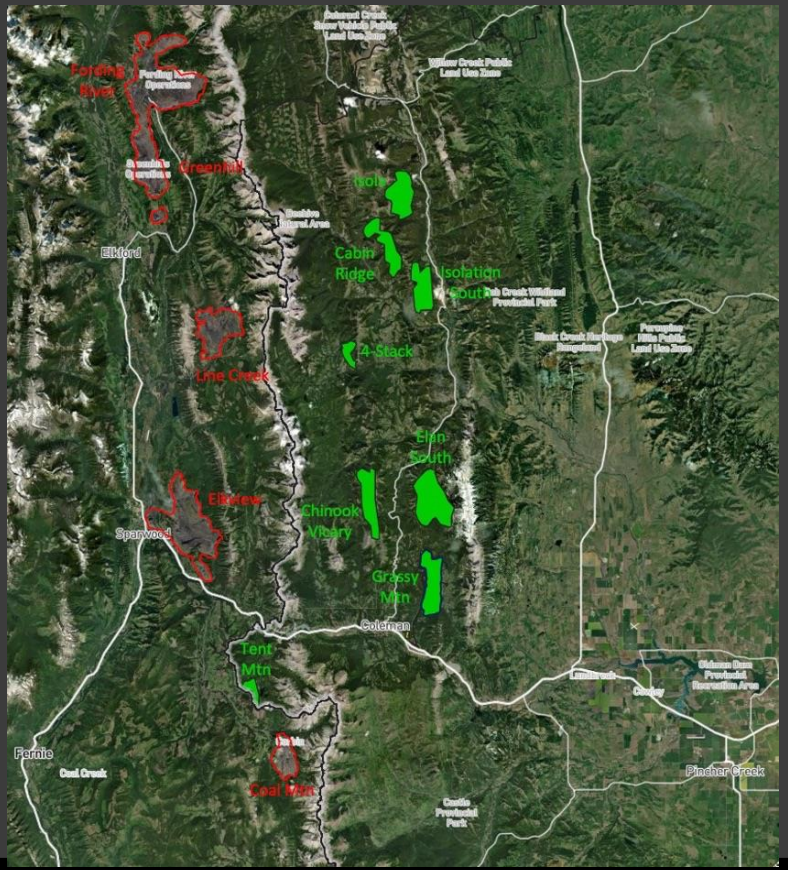


Figure 3. The headwater position of the Oldman River Watershed in the Saskatchewan River basin that provides water to southern Alberta, Southern Saskatchewan and Manitoba. Source: Oldman Watershed Council website.

Coal Lease Sites and Proximity to the Elk Valley





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Physical and Climatic Patterns

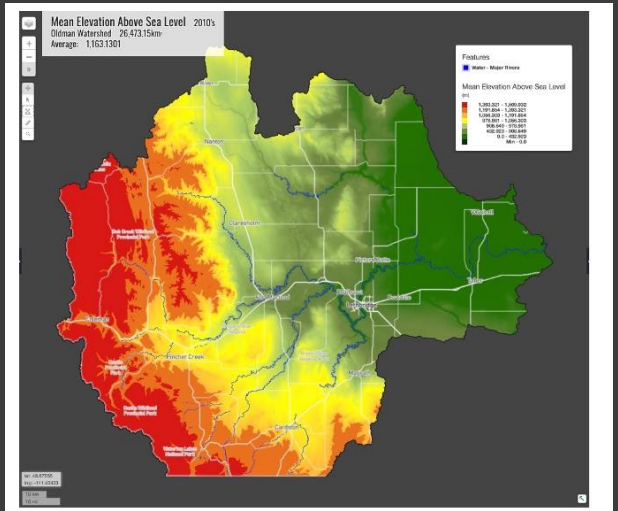

Figure 12. Spatial variation in elevation of the ORW drives regional diff Online.

Elevation

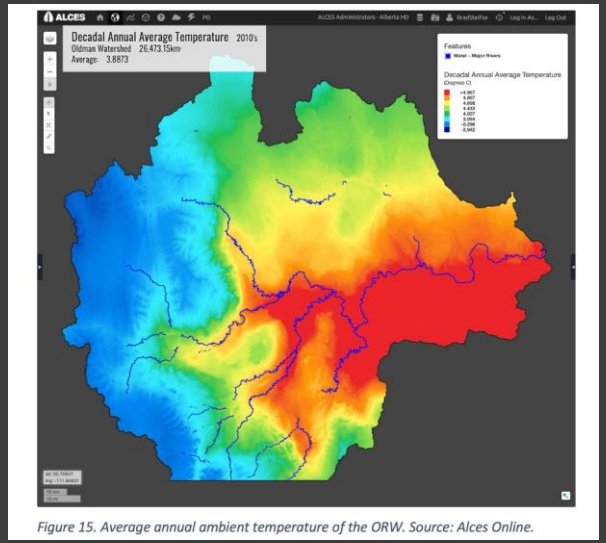

Figure 15. Average annual ambient temperature of the ORW. Source: Alces Online.

Temperature

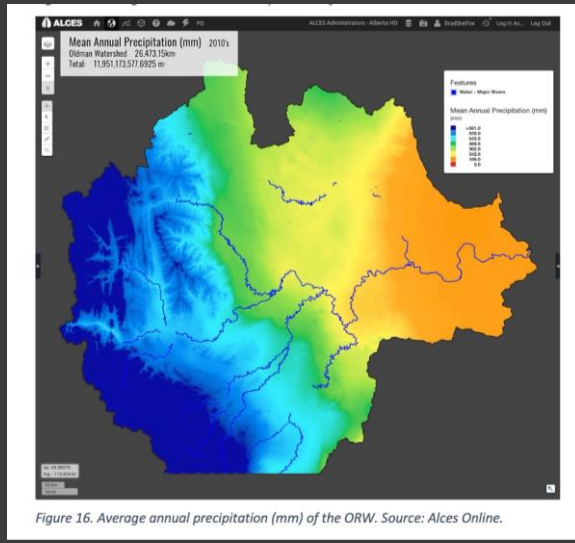

Figure 16. Average annual precipitation (mm) of the ORW. Source: Alces Online.

Precipitation

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Contribution to Streamflow (left) and Water Use (right)

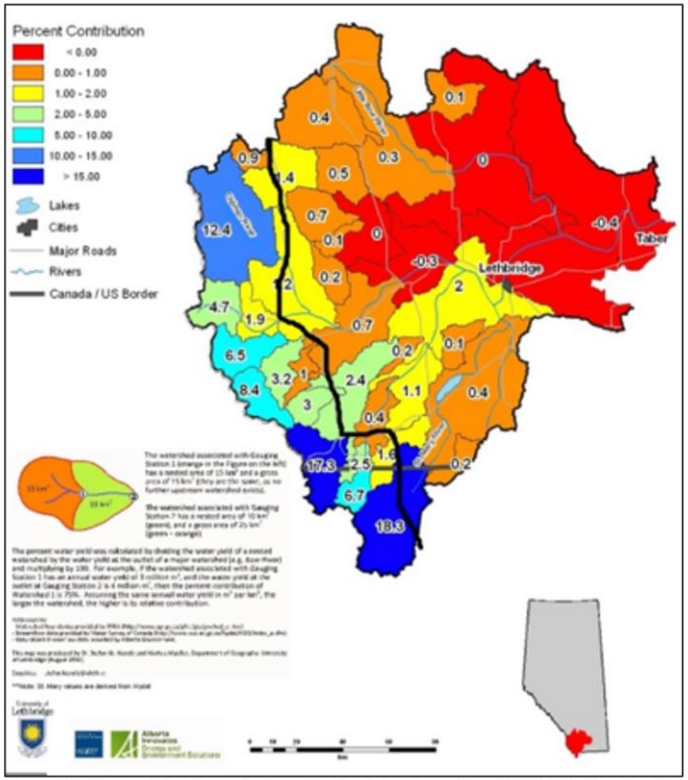
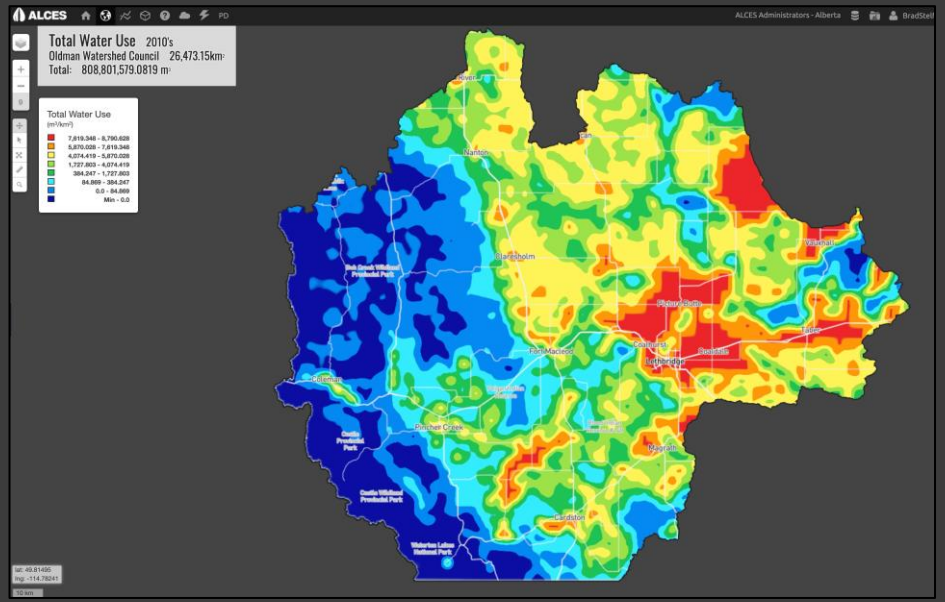


Figure 20. The contributions of sub-watersheds to streamflow (1971-2000) in the Oldman
Kienzle; presented in the State of the Oldman River Watershed; Oldman Watershed Cour



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A Long-Standing Recognition of the Primacy of Watershed Protection

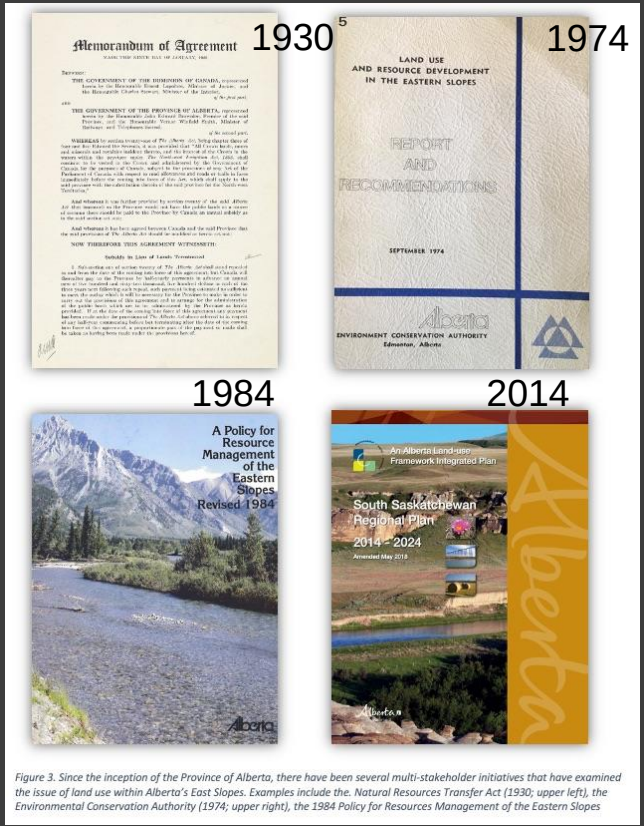

Figure 3. Since the inception of the Province of Alberta, there have been several multi-stakeholder initiatives that have examined the issue of land use within Alberta's East Slopes. Examples include the. Natural Resources Transfer Act (1930; upper left), the Environmental Conservation Authority (1974; upper right), the 1984 Policy for Resources Management of the Eastern Slopes

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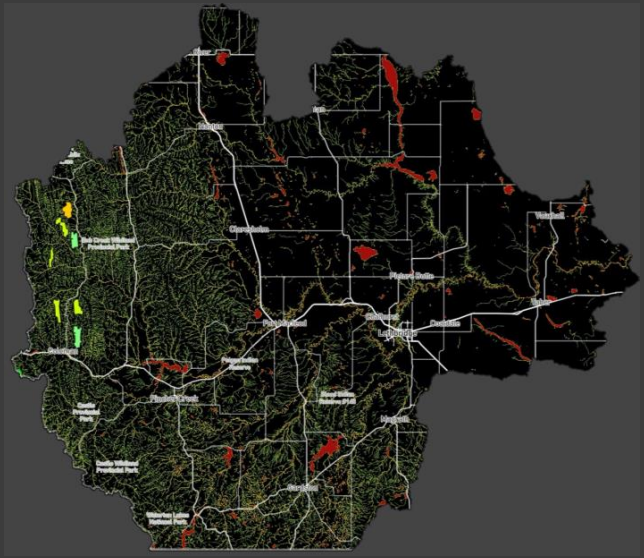
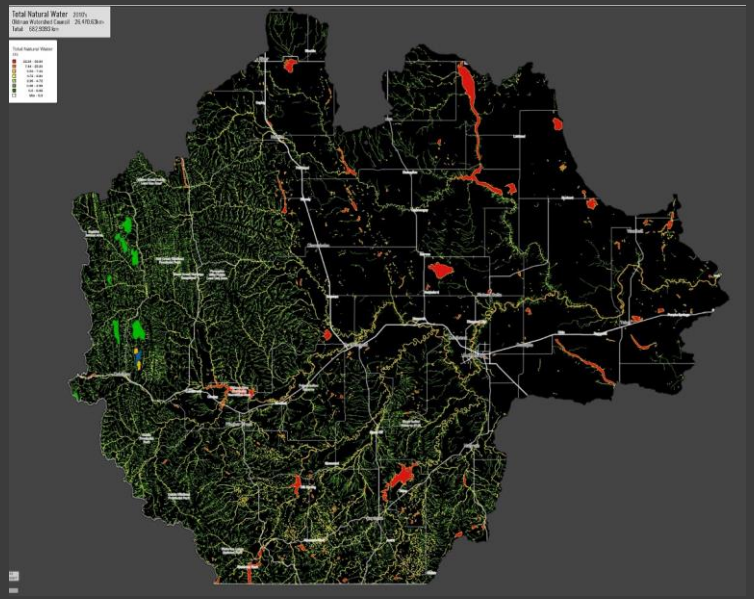
Water Flow and Water Demand Network



Understanding the Plumbing Math



The Math

Ave Precipitation	11.9 (8-16)	B m^3
Ave Water Yield (runoff)	3.2 (2.8-4.2)	B m^3
Ave to Saskatchewan	1.6	B m^3

	Allocated	Use	Units
Irrigation	1.8	1.2	B m^3
Municipal		.06	B m^3
Cattle		.017	B m^3
Total	2.0	1.3	B m^3

Variance in Precipitation and Water Flow

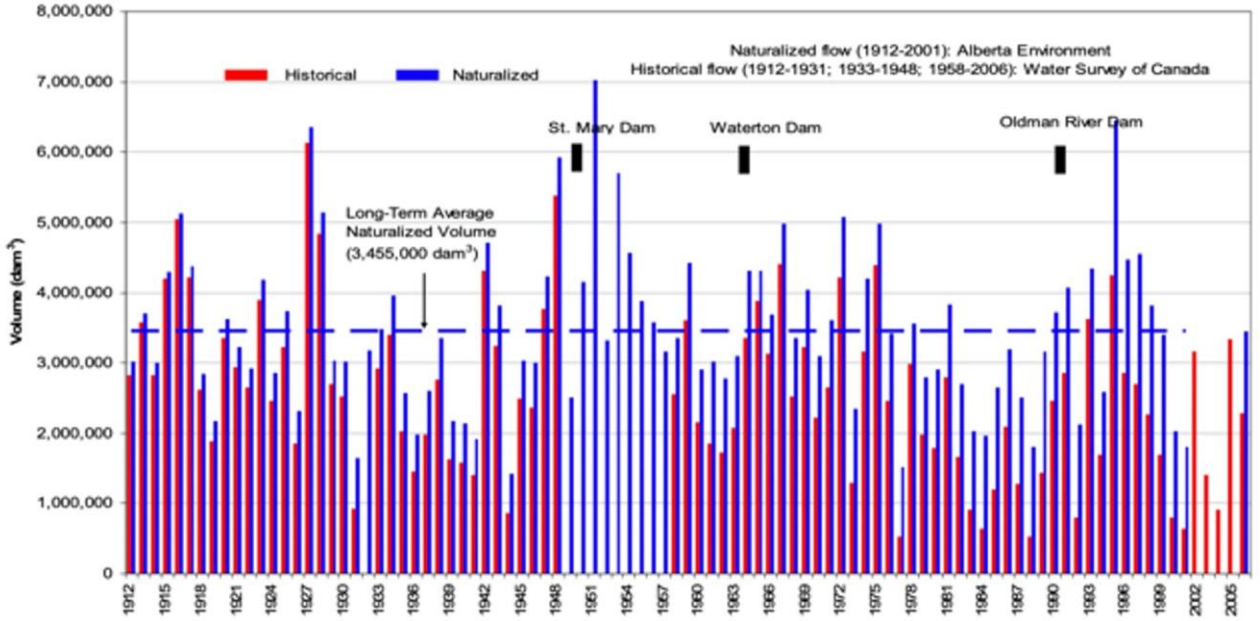


Figure 18. Annual Historical and Naturalized flow volume of the ORW near Lethbridge, Alberta. Source: https://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/irr13053/$FILE/ssrb_main_report.pdf. Naturalized flow values estimate the water flow in the absence of extractive human land uses. Historical records reflect the actual measured flow volumes and hence incorporate the effects of land uses and their water extractions. Note frequently occurring drought years where flow is less ¼ of average.

Climate Change and Seasonal Streamflow

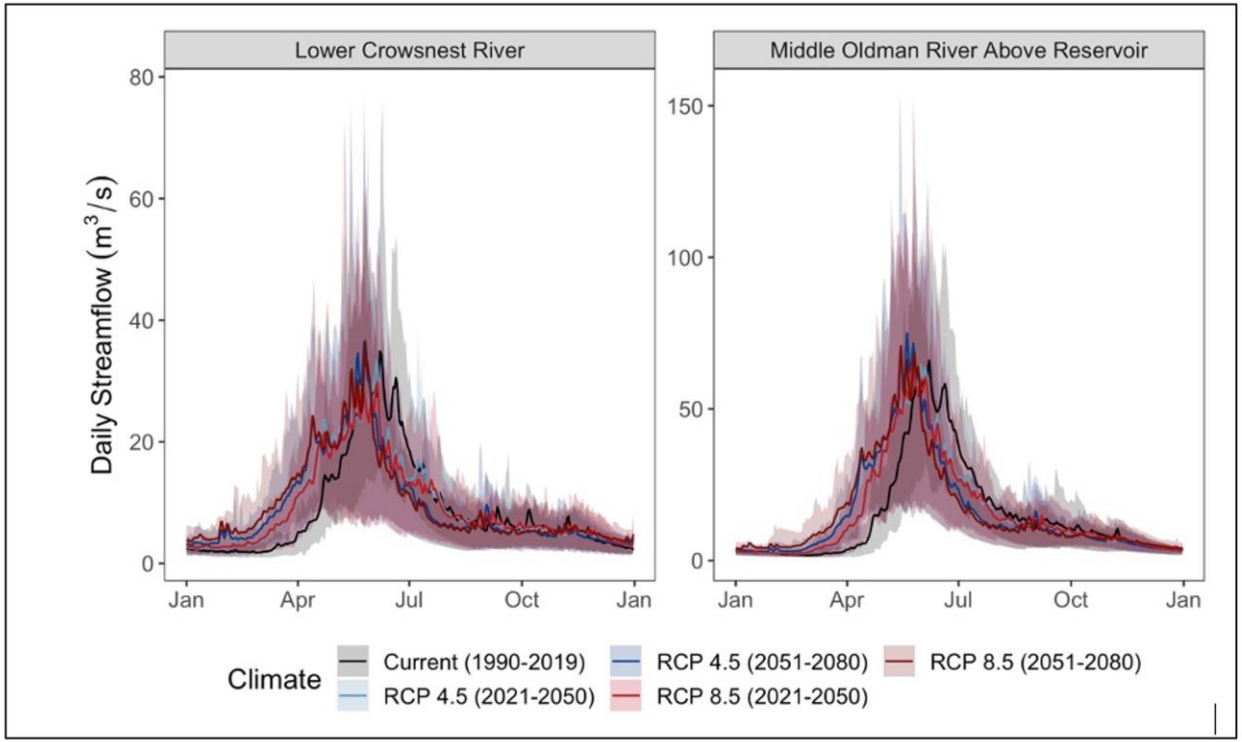


Figure 114. Daily streamflow for two major tributaries in the Oldman River under current conditions and future climate change scenarios. Solid lines correspond to the average while shaded areas correspond to 10-90% quantiles. Note that late summer flows decline markedly as runoff shifts to earlier in the year.

Scenarios and Indicators

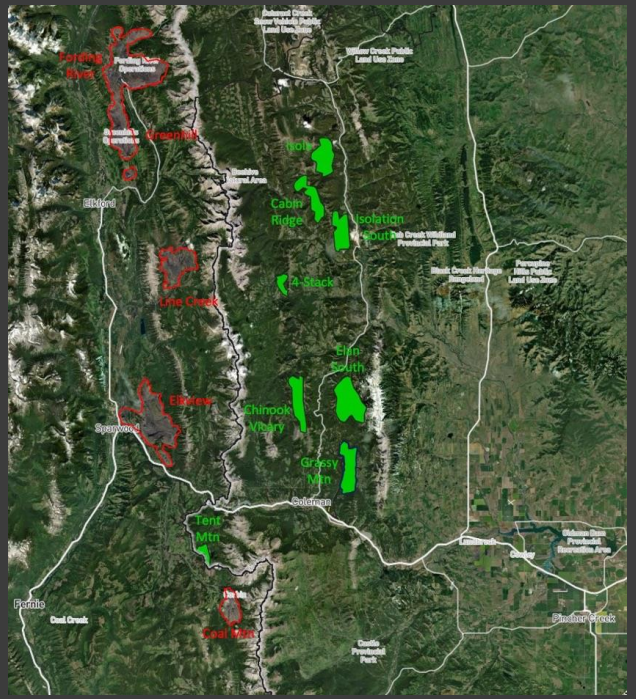
Table 5. Matrix of "what-if" simulations involving coal mining, climate change and land use change, examined in this study. Coal MTA values reflect maximum annual values.

Scenarios	Coal Trajectory	Climate Change
Scenario 1	Low (None)	As per Current
Scenario 2	Medium (5.875 MTA; Grassy & Tent)	As per Current
Scenario 3	High (~23.95 MTA; 8 mines)	As per Current
Scenario 4	Low (None)	Climate Change (RCP 4.5)
Scenario 5	Medium (5.875 MTA; Grassy & Tent)	Climate Change (RCP 4.5)
Scenario 6	High (~23.95 MTA; 8 mines)	Climate Change (RCP 4.5)

Environmental Indicators

- Water Supply
- Water Demand
- Water Quality (Selenium)
- Biodiversity (Cutthroat Trout)
- Landscape Integrity

How much coal mining are we talking about?



Prospective Coal Project Name	Low Growth Scernario	Medium Growth Scenario	High Growth Scenario	Coal Project Lease Area (ha)	Cumulative Area of Disturbance (ha)	Proposed Lifespan yrs	Ave Annual Coal Production (tonne/yr)	Maximum Annual Coal Production (tonne/yr)	Cumulative Coal Production (MT)	Proven or Indicated Coal Resources (tonnes)
Grassy Mountain Coal Project		x	x	8,330	1,244	25	4,026,609	4,706,000	92,612,000	1,125,000,000
Tent Mountain Project		x	x	1,931	364	14	1,020,639	1,198,600	14,288,950	22,000,000
Elan South Coal Project			x	13,000	1,261	22	3,997,701	5,293,179	91,947,116	47,000,000
Isolation South Coal Project			x	6,239	1,278	21	5,528,137	6,000,000	127,147,151	112,000,000
Cabin Ridge Project Ltd			x	5,000	1,276	23	3,997,701	5,293,179	91,947,116	100,000,000
Isola Coal Project			x	4,832	1,354	25	3,997,701	5,293,179	91,947,116	100,000,000
4-Stack Coal Project			x	1,965	1,235	25	3,997,701	5,293,179	91,947,116	100,000,000
Chinook (Vicary) Coal Project			x	10,000	1,334	25	3,997,701	5,293,179	91,947,116	149,000,000
Totals				51,297	9,346		13,875,674	23,948,137	693,783,680	1,755,000,000

Lease Area	512 km^2, about 2% of entire Basin
Direct Mine footprint	93.4 km^2
Maximum Coal Production	~24 MTA
Cumulative Coal Production	~693 Million Tonne
Cumulative Waste Rock	~6 Billion Tonne
Cumulative CO_2e Emission	~2 Billion Tonne

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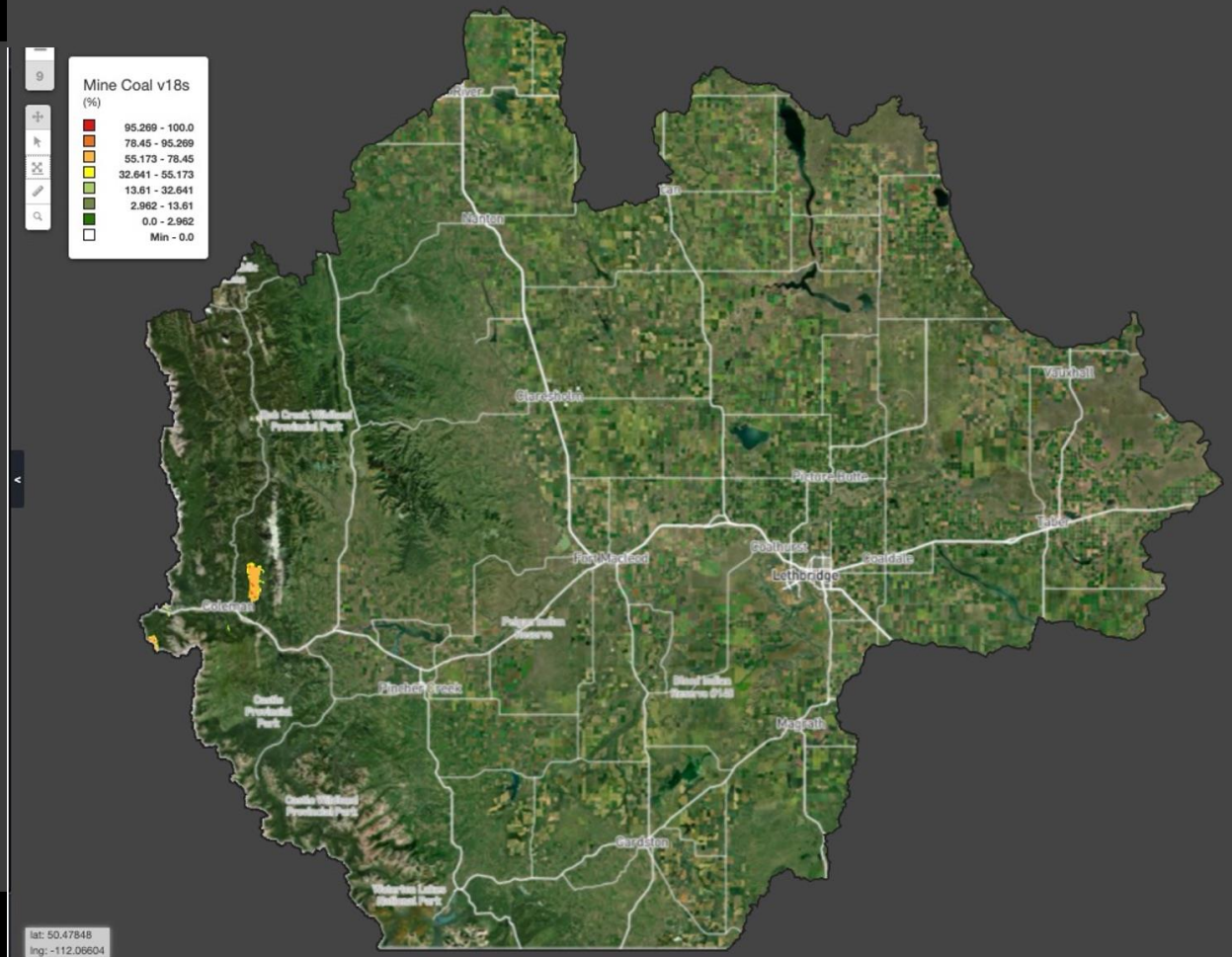

Statistical Readouts for 2060's

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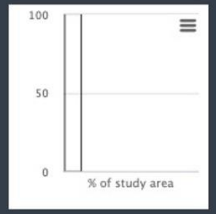
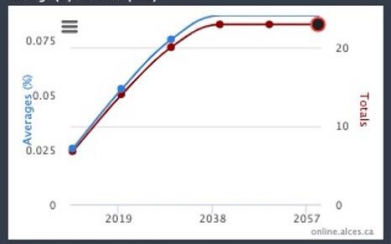
Mean: 0.0865
Median: 0
Kurtosis: 1,165.7126



Average (%) and Total (km2)



Add Band | Remove Bands | Y Axis Min = 0

This cover type is part of the 2018 summary unity layer. It is calculated as the sum of the following cover types from the detailed unity layer: Mine Coal v18

Statistical Readouts for 2010's

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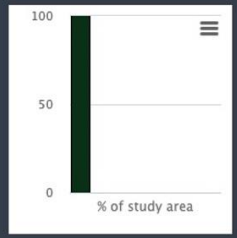
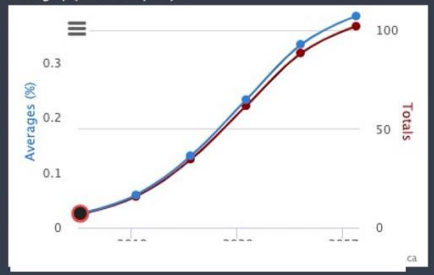
Mean: 0.0258
Median: 0
Kurtosis:3,923.5628



Average (%) and Total (km2)



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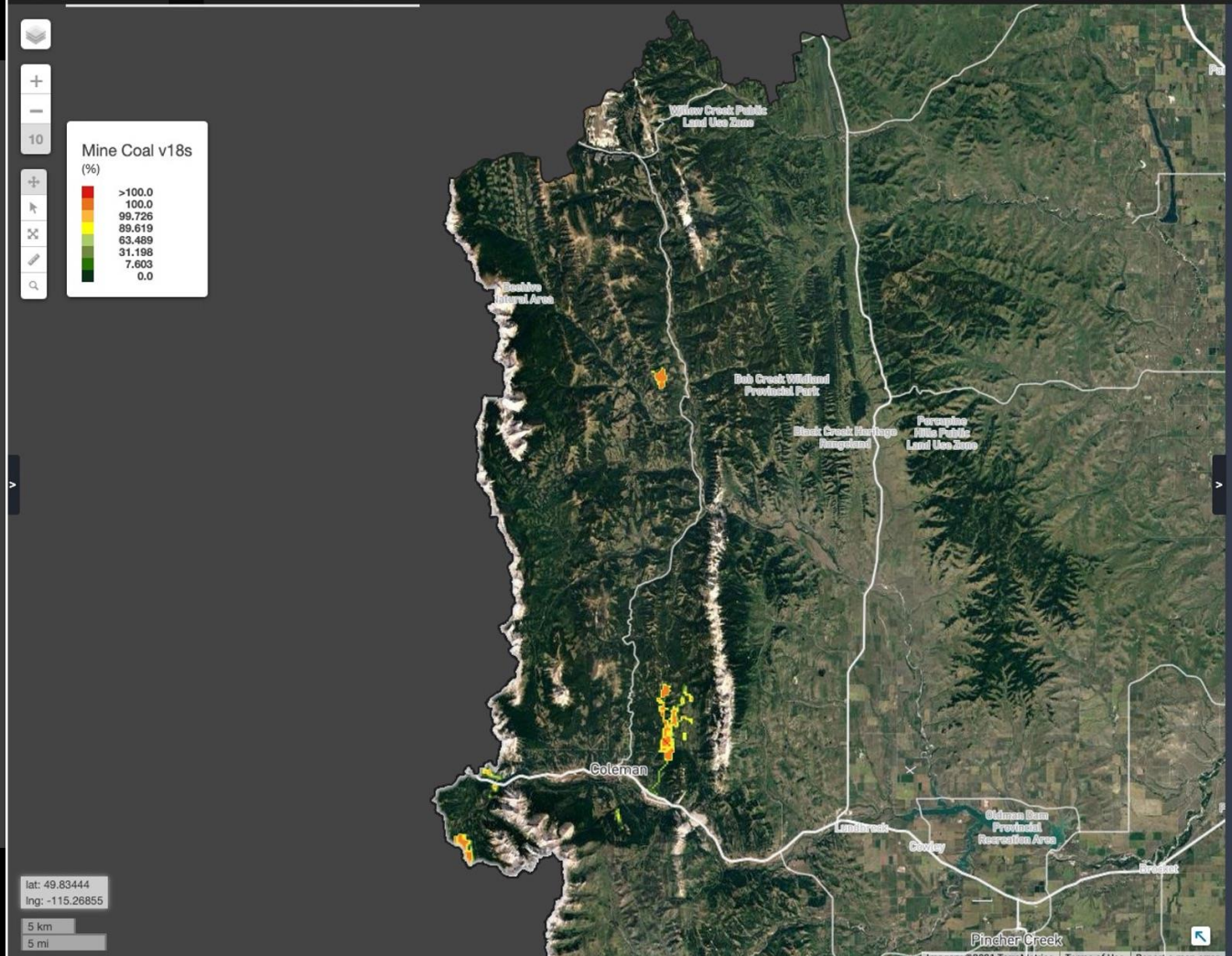

Statistical Readouts for 2020's
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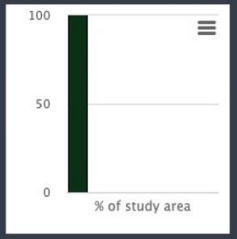
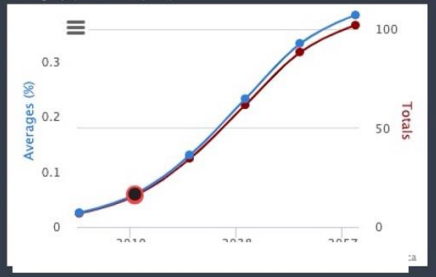
Kurtosis:1,745.5092



Average (%) and Total (km2)



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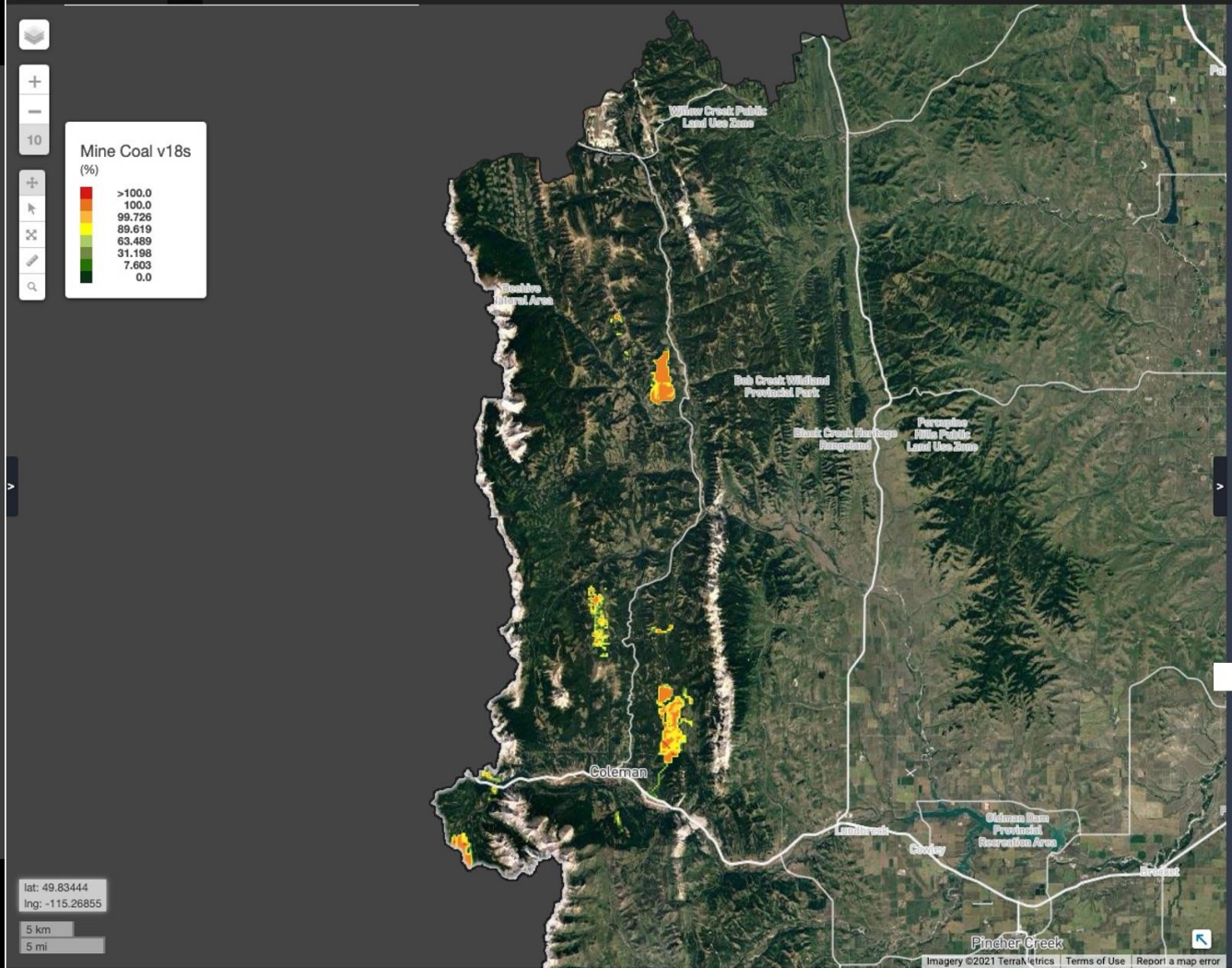

Statistical Readouts for 2030's
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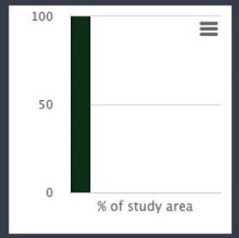

Average (%) and Total (km2)

Add Band | Remove Bands | Y Axis Min = 0

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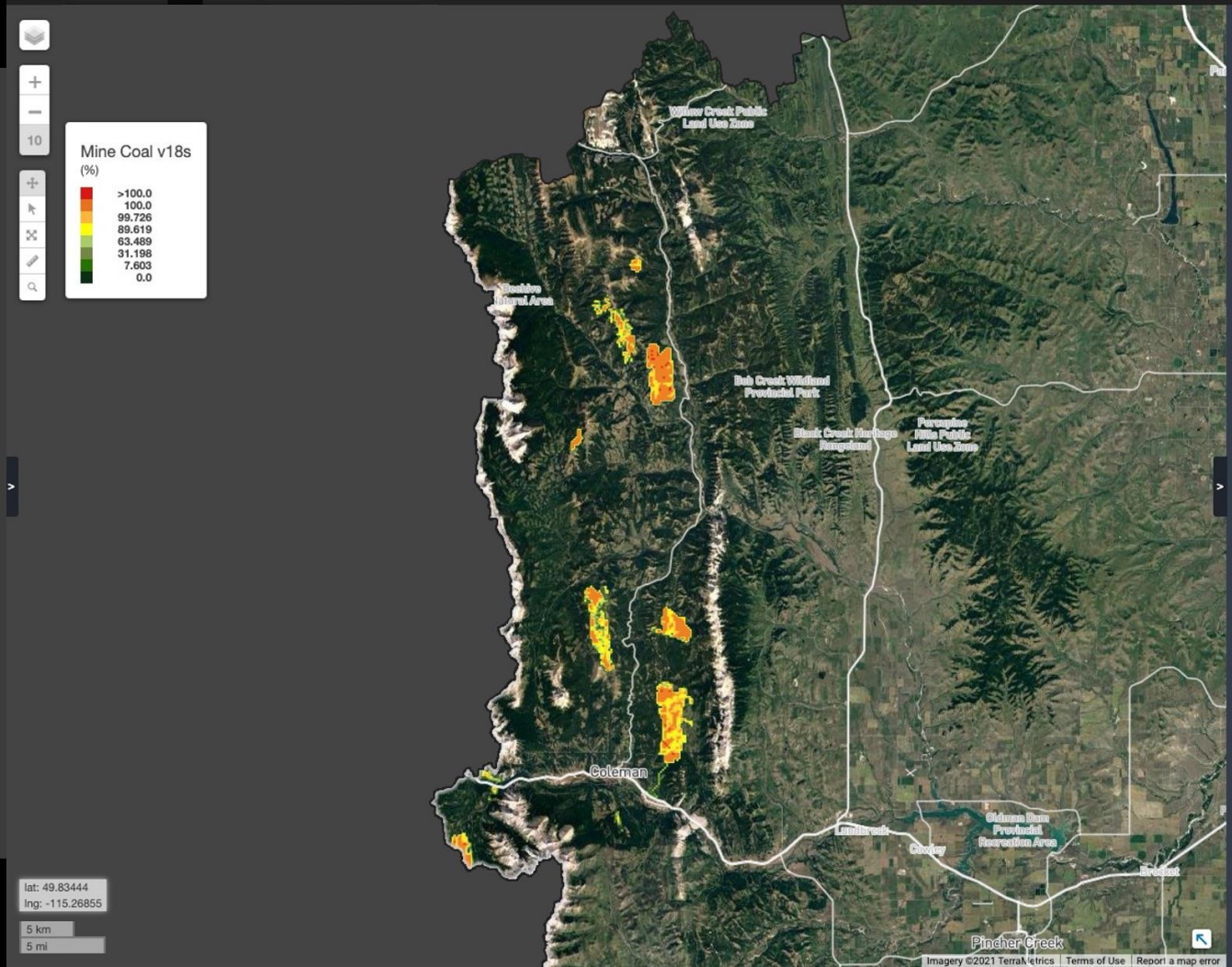

Statistical Readouts for 2040's

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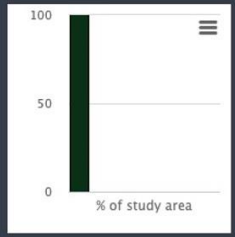
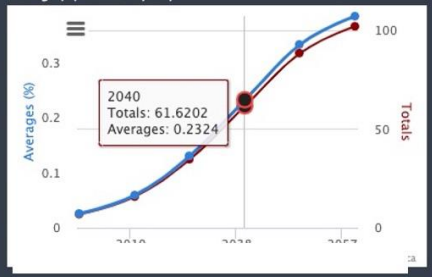


Average (%) and Total (km2)



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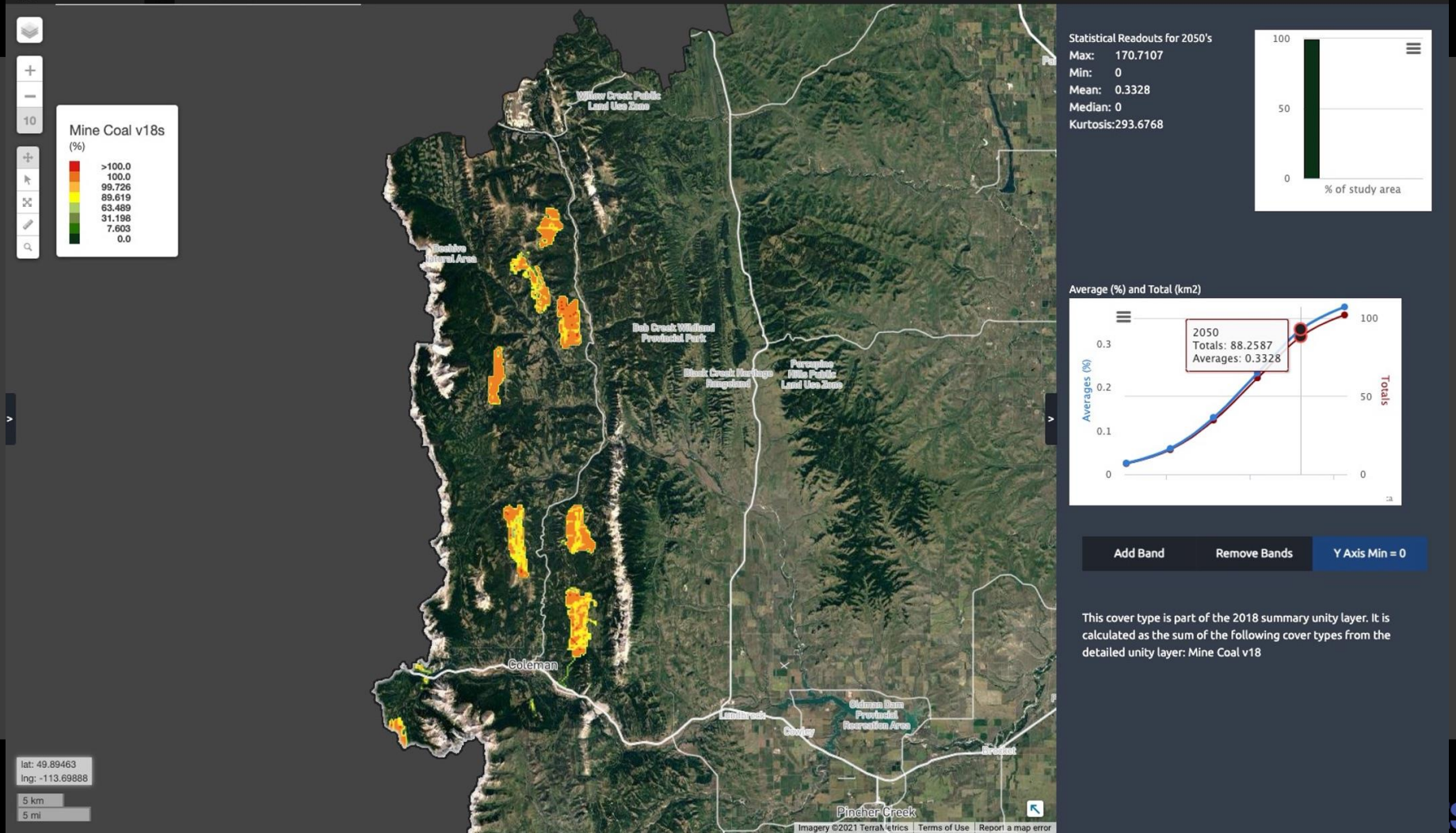

Statistical Readouts for 2050's
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Mean: 0.3328
Median: 0
Kurtosis:293.6768

Average (%) and Total (km2)

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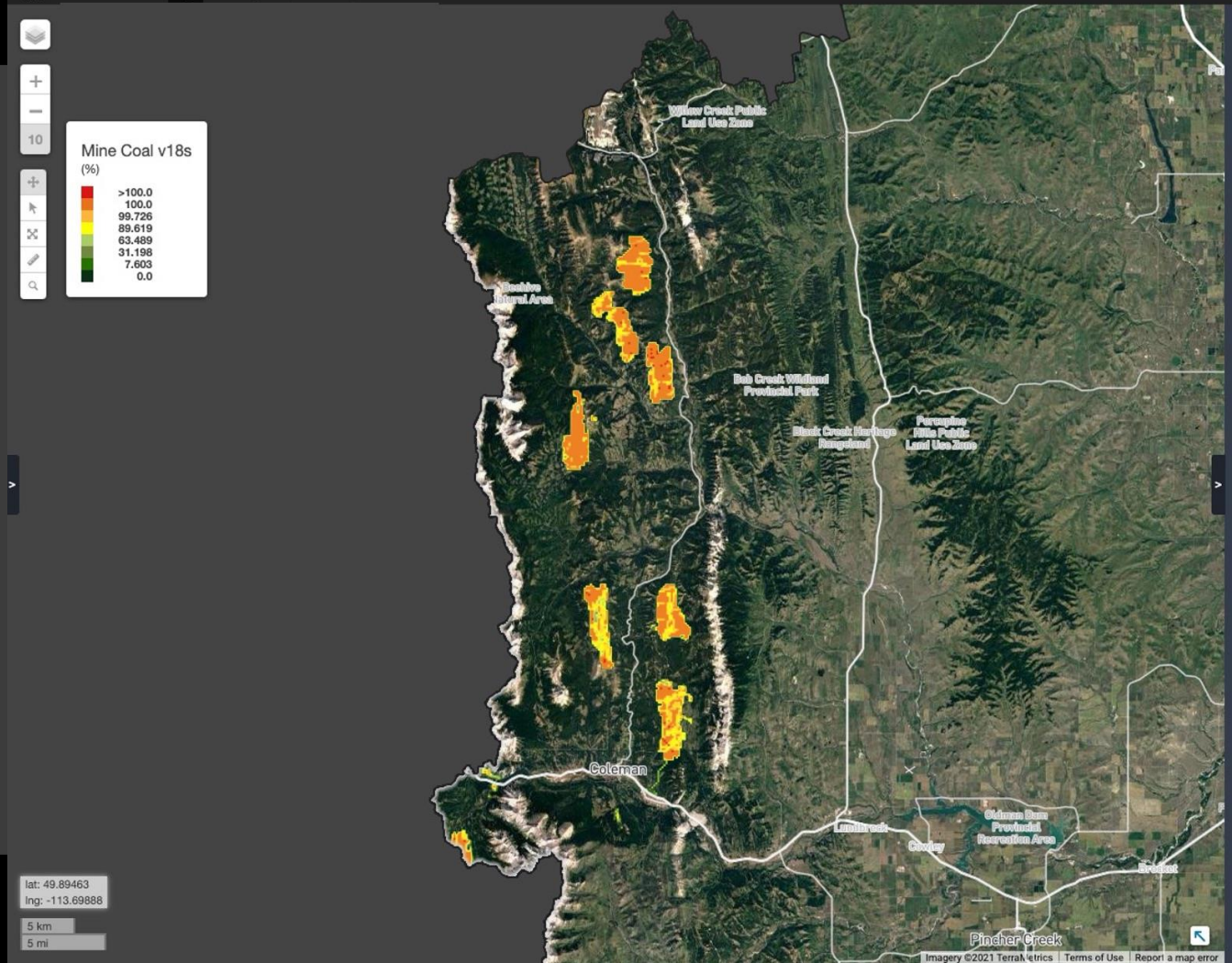

Statistical Readouts for 2060's

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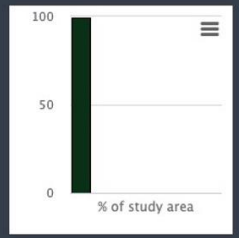
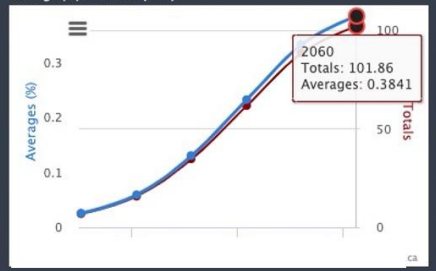


Average (%) and Total (km2)



Add Band | Remove Bands | Y Axis Min = 0

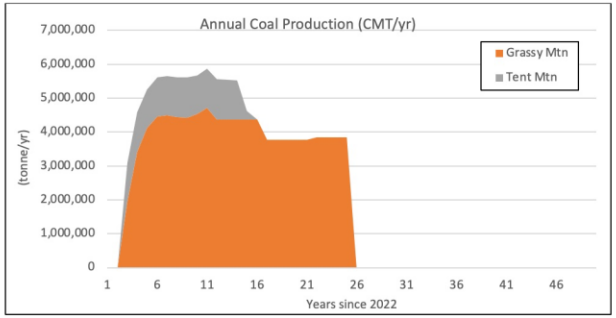
This cover type is part of the 2018 summary unity layer. It is calculated as the sum of the following cover types from the detailed unity layer: Mine Coal v18

Coal Production

Coal Production

In the medium coal development scenario, coal production (CMT) rapidly grows to a maximum of ~5.84 M tonne/year (~Year 10-12) with annual productions varying between 3.8 and 5.5 M tonne throughout the 20-25 year production lifespan (Figure 81). Cumulative coal production is ~107 M tonne (Figure 81).

In the high coal development scenario, coal production grows rapidly during the first 25 decades and peaks at ~23.9 M tonne/year (~Year 20-25). Cumulative coal production is ~693.7 M tonne (Figure 82).



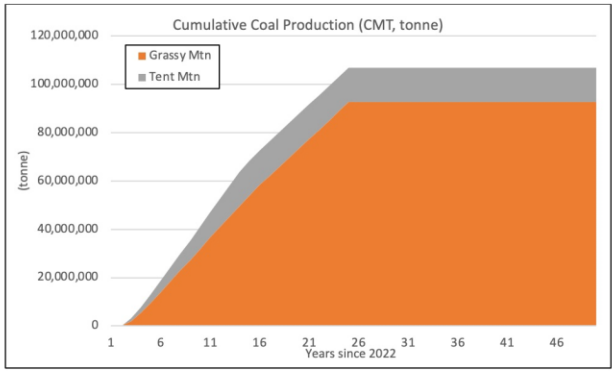
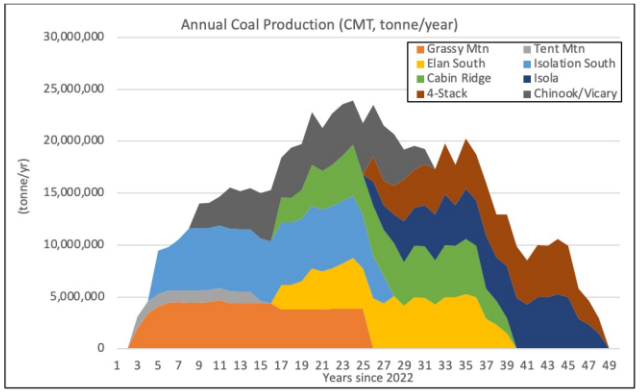


Figure 81. Annual (upper) and cumulative (lower) production (tonne) of clean coal under the Medium Growth Scenario.



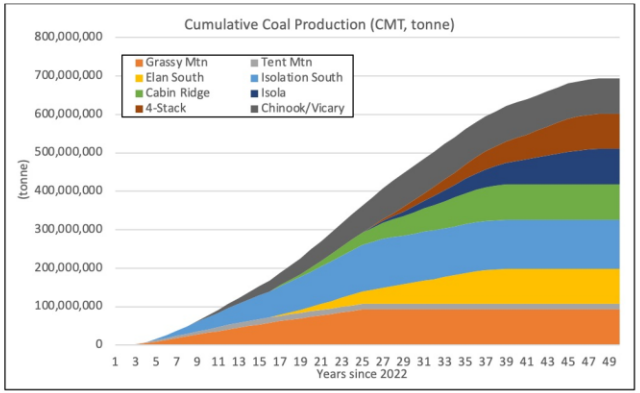


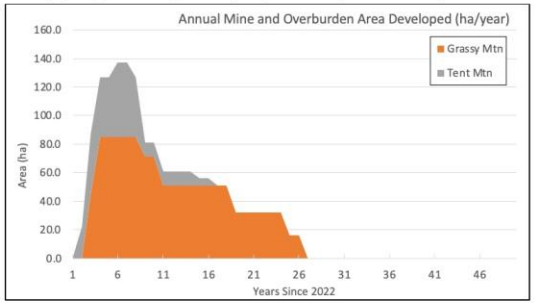
Figure 82. Annual (upper) and cumulative production (tonne) of clean coal under the High Growth Scenario.

Disturbance Area

Disturbance Area

In the medium coal development scenario, the initial 2021 coal mine footprint (from legacy mines of Grassy Mtn, Tent Mtn) of 6.84 km², grows by an additional area of ~16.00 km² by the end of 5 decades (Figure 79). The decade by decade trajectory of this development is shown in Figure 80.

In the high coal development scenario, the disturbance area of coal mining grows to 9,411 ha by the end of 5 decades (Figure 80). The decade by decade trajectory of this development is shown in Figure 80.



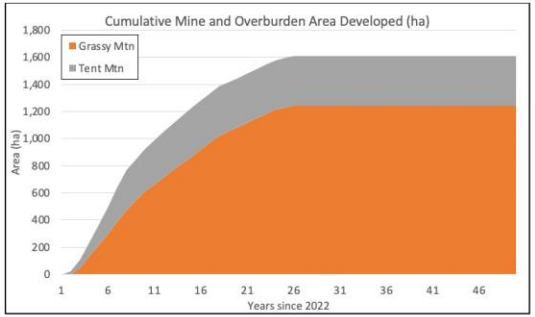


Figure 79. Annual (upper) and cumulative (lower) area of active coal mining under the Medium Growth Scenario.

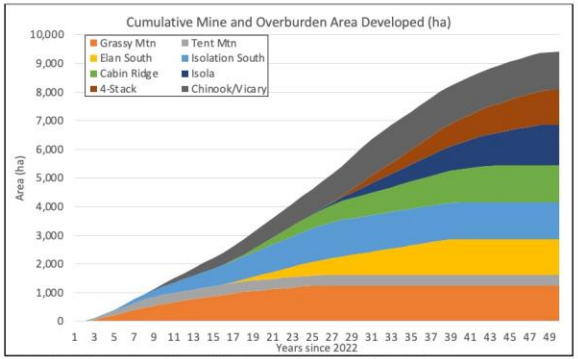


Figure 80. Annual (upper) and cumulative area (lower) of coal mining under the High Growth Scenario.

Waste Rock Production

Waste Rock Production

In the medium coal development scenario, waste rock displacement grows rapidly to a maximum of ~65 M m^3/year (~Year 10-12) with annual productions varying between 40 and 55 M m^3 throughout the 20-25 year production lifespan (Figure 83). Cumulative waste rock production and displacement is ~1.1 B m^3 (Figure 83).

In the high coal development scenario, waste rock displacement grows rapidly to a maximum of ~200 M m^3/year (~Year 10-12) with annual productions typically varying between 80 and 120 M m^3 throughout the 50 year production lifespan (Figure 84). Cumulative waste rock production and displacement is ~6 B m^3 (Figure 84).

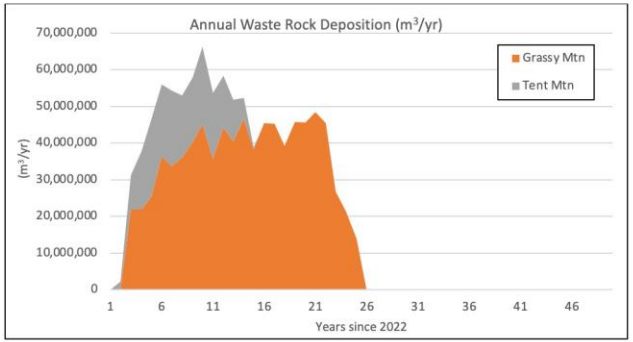
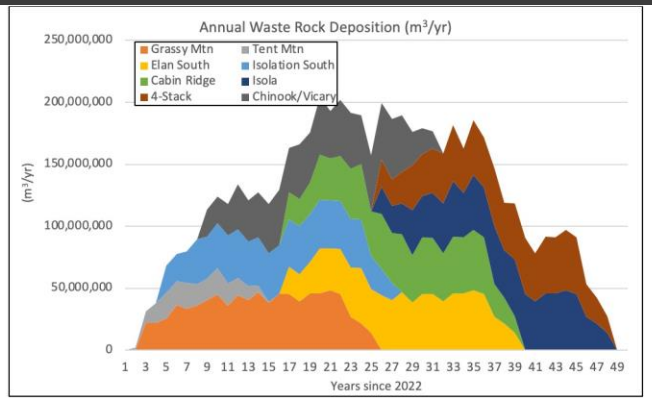


Figure 83. Annual (upper) and cumulative (lower) production (tonne) of waste rock under the Medium Growth Scenario.



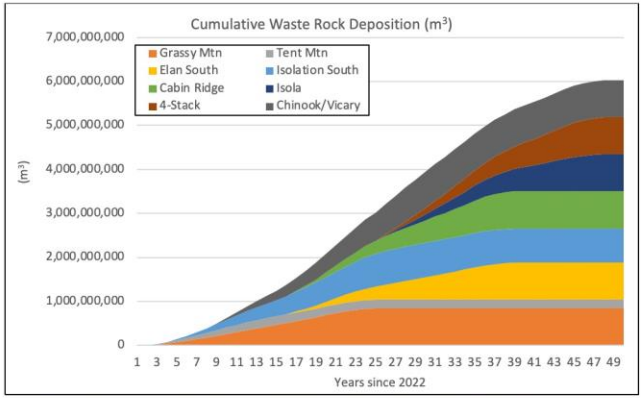


Figure 84. Annual (upper) and cumulative (lower) production (tonne) of waste rock under the High Growth Scenario.

How much displaced volume are we talking about

Crowsnest Mtn

1,000,000,000 m^3 = 1 km^3

1.23 km^3

Medium Coal Scenario
(just Grassy Mtn and Tent Mtn)

1.3 B m^3 = 1.3 km^3

~Equivalent in volume to 1.1 x Crowsnest Mtn

High Coal Scenario
(all 8 mines)

6.7 B m^3 = 6.7 km^3

~Equivalent in volume to about 5.2 Crowsnest Mtns

Selenium Loading

Selenium Loading

In the medium coal development scenario, annual selenium production (load) grows in a linear manner from years 1-22 and levels off at ~2.75 tonne/year (=2,750 kg/yr or 2.75 M grams/year) throughout the remaining 50 year simulation (Figure 86). Cumulative selenium production during the 5 decade simulation exceeds 100 tonne of selenium (Figure 86).

In the high coal development scenario, annual selenium production (load) grows consistently throughout the 5 decade simulation, and achieved annual production rates exceeding 10 tonne/year by Year 50. Average annual rates are ~5.6 tonne/year throughout the 50 year simulation (Figure 87). Cumulative selenium production during the 5 decade simulation exceeds ~280 tonne of selenium (Figure 87).

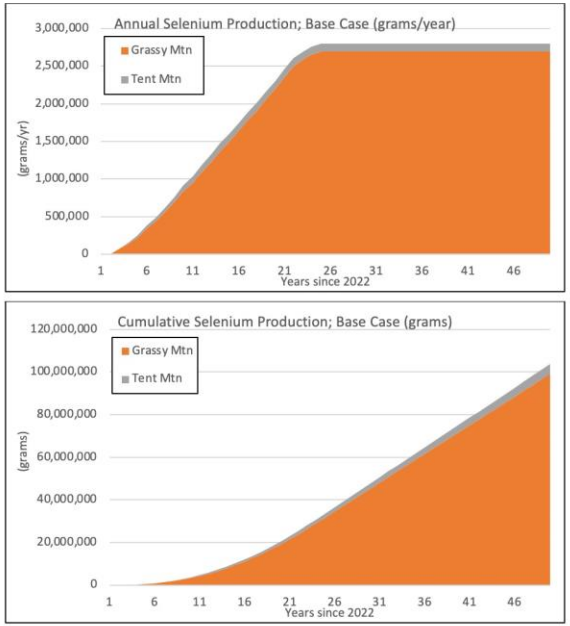


Figure 86. Annual (upper) and cumulative(lower) production (grams) of selenium (Se) under the Medium Growth Scenario.

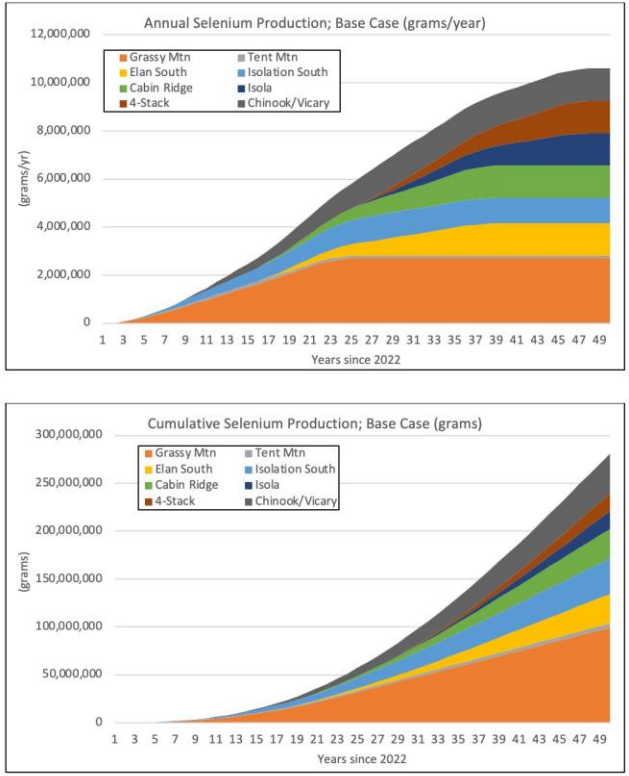


Figure 87. Annual (upper) and cumulative (lower) loading (grams) of selenium (Se) under the High Growth Scenario.

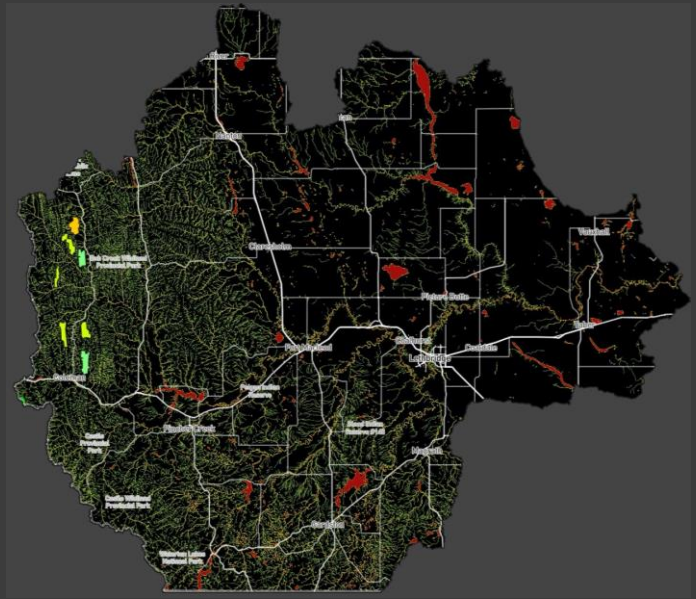
Selenium Attenuation Rates required to meet water quality guidelines

Table 9. Minimum selenium attenuation rate required to meet various water quality guidelines at selected affected waterways in the Oldman River watershed under the High mine development scenario.

Site	Peak Annual Average Concentration (µg/L)	BC - Drinking Water	BC - Irrigation	Canada - Drinking Water	GoA - Aquatic Life	GoA - Irrigation (continuous)
Blairmore Creek	878	99%	99%	94%	100%	98%
Dutch Creek	151	93%	93%	67%	99%	87%
Racehorse Creek	138	93%	93%	64%	99%	86%
Livingstone River	135	93%	93%	63%	99%	85%
Racehorse Creek Near The Mouth	95	90%	90%	48%	98%	79%
Middle Oldman River Above Reservoir	93	89%	89%	46%	98%	79%
Upper Crowsnest River	92	89%	89%	46%	98%	78%
Upper Oldman River Above Reservoir	70	86%	86%	28%	97%	71%
Lower Oldman River Above Reservoir	57	82%	82%	12%	96%	65%
Lower Crowsnest River	41	76%	76%	0%	95%	52%
Crowsnest River Above Crowsnest Lake	20	50%	50%	0%	90%	0%
Oldman River at Lethbridge	20	50%	50%	0%	90%	0%

Microgram/ liter

% of Streamflow allocated and consumed by coal mining



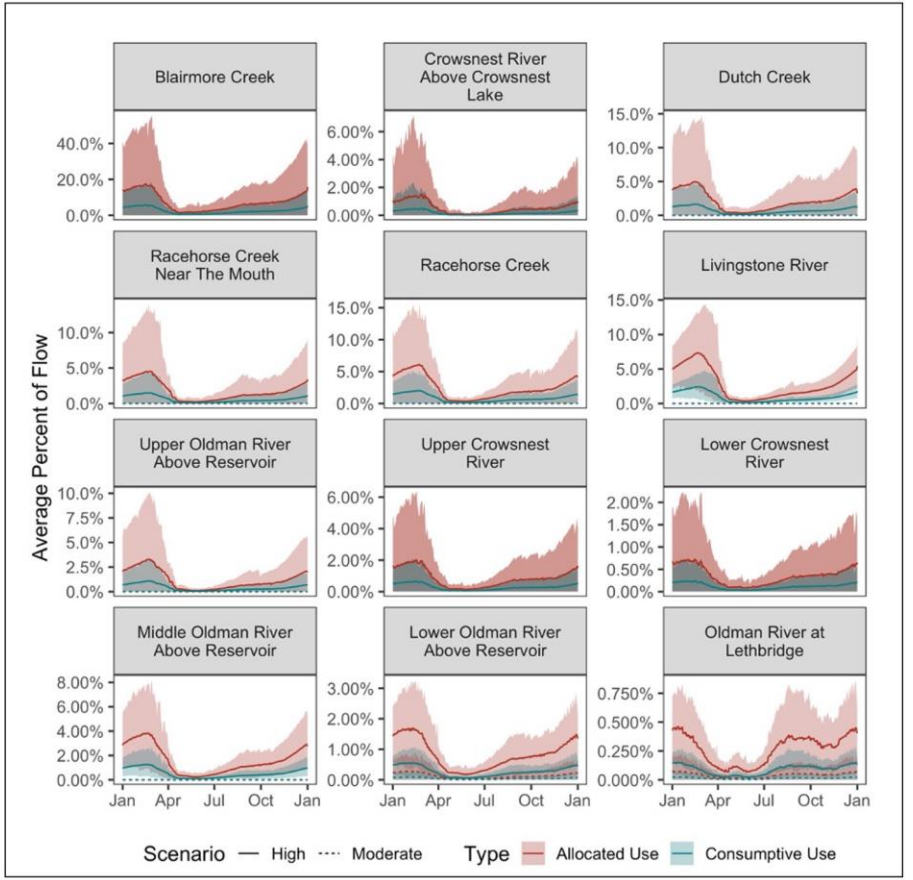


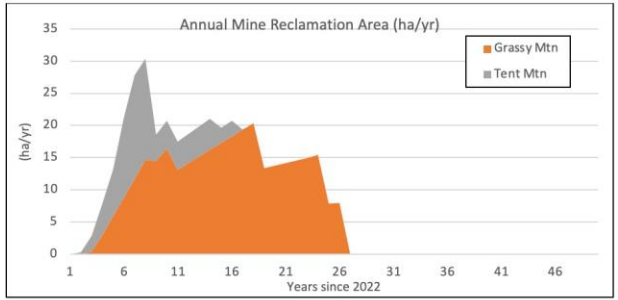
Figure 115. Percent of streamflow allocated and consumed under each mining scenario under the averaged future climate change projections. Solid lines represent the average over the 2025-2069 period while the shades lines represent the 10-90% quantiles (i.e. in four out of five years values are within this shaded area).

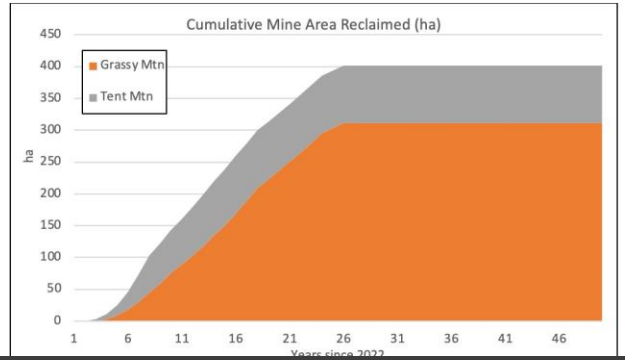
Mine Reclamation Area

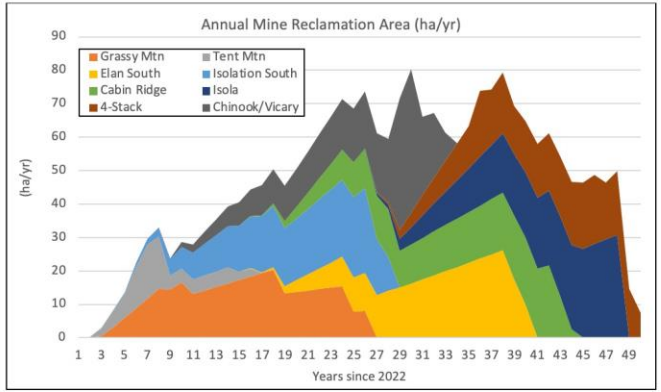
Mine Reclamation Area

In the medium coal development scenario, the amount of reclaimed area increases to 20-30 ha/yr during decades 1 and 2 (Figure 92). Cumulative area reclaimed at the end of the simulation is 400 hectares which approximates 25% of the total disturbed area (Figure 92). In a more practical sense, the cumulative reclamation area is likely to be distributed over a longer period of time.

In the high coal development scenario, the amount of reclaimed area increases to values of 40-70 ha/yr during the full simulation period (Figure 93). Cumulative area reclaimed at the end of the simulation is 2,405 ha which approximates 25% of the total disturbed area (Figure 93). The cumulative amount of area disturbed and reclaimed for the high growth scenario is illustrated in Figure 94.







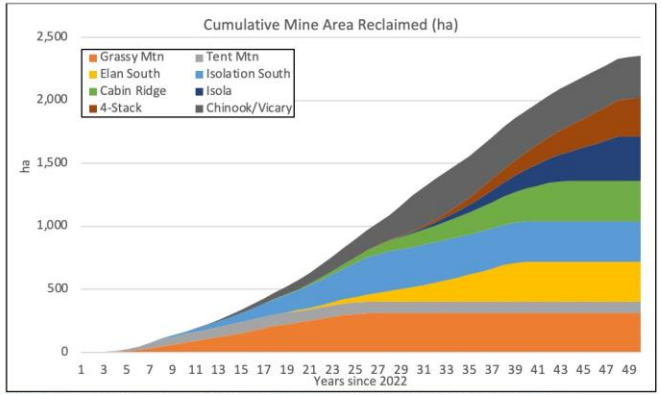


Figure 93. Annual (upper) and cumulative (lower) area (ha) of reclaimed mine site under the High Growth Scenario.

Reclamation Trajectory

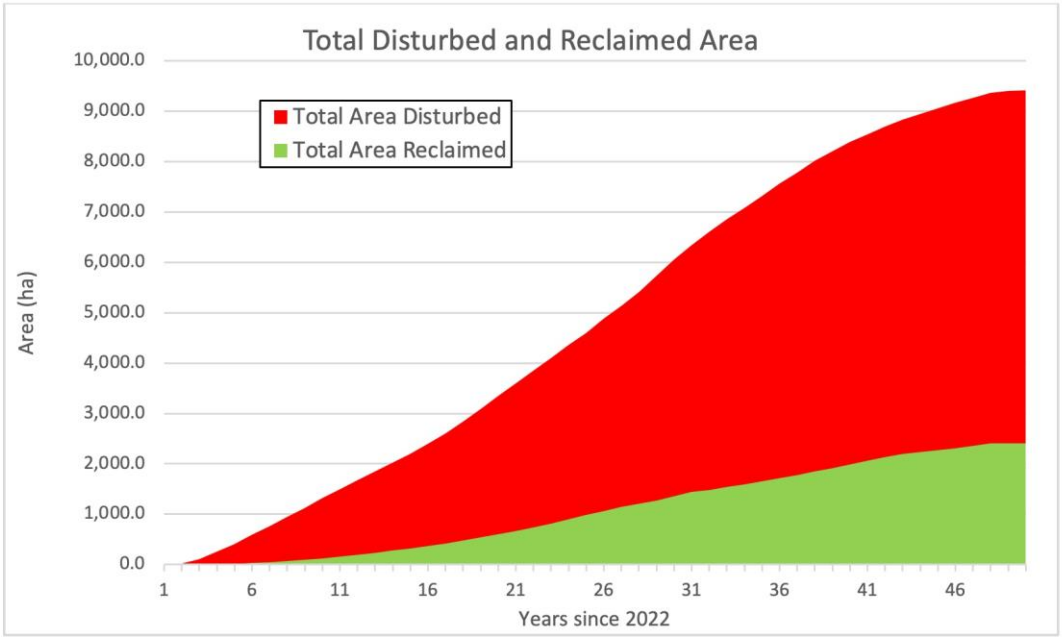


Figure 94. Cumulative area disturbed (red) and area reclaimed (green) for the high growth coal scenario

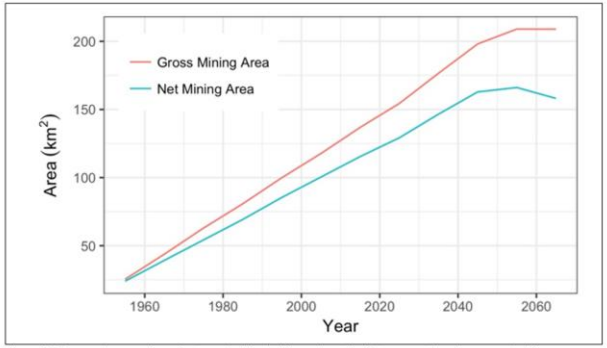


Figure 59. Temporal comparison of net coal mining (taking reclamation into account) and gross coal mining footprint area in the Elk Valley. Source: https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/cumulative-effects/draft_elk_valley_ceam_12122018.pdf. The difference between the gross mining area (red line) and the net mining area (blue line) reflects the ~25% of mining area that was reclaimed after 50 years of mining.

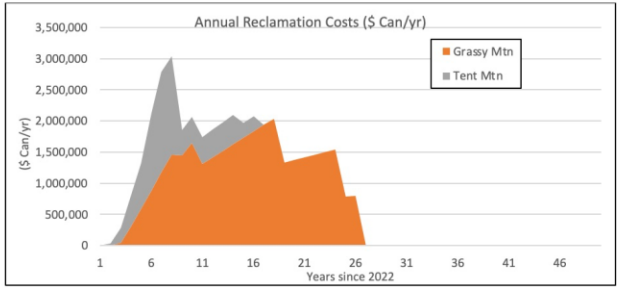
Mine Reclamation Costs

Mine Reclamation Costs

In the medium coal development scenario, reclamation costs vary between $1.5-3.0 M/yr during decades 1-3 (Figure 95). Cumulative reclamation costs over the simulation are $40 M, which contributes to the reclamation of ~25% of the total disturbed area (Figure 94). In a more practical sense, the cumulative reclamation costs are likely to be distributed over a longer period of time.

In the high coal development scenario, reclamation costs vary between $3-8 M/yr during decades 1-5 (Figure 96). Cumulative reclamation costs over the simulation are $235 M, which contributes to the reclamation of ~25% of the total disturbed area (Figure 94).

There is uncertainty about the actual reclamation costs associated with attaining a defined post-mine reclamation performance. This variance (from $25K/ha (low), to $100K/ha (medium), to $175K/ha (high)) is expressed in Figure 97 (medium growth scenario) and Figure 98 (high growth scenario).



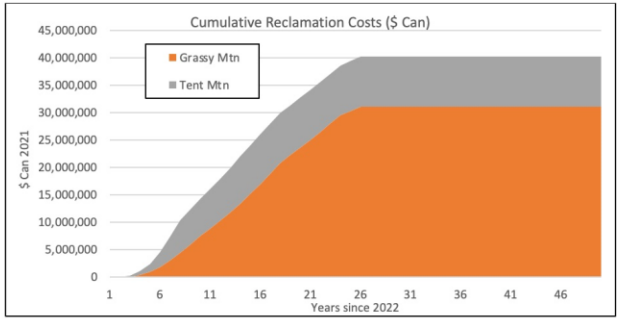
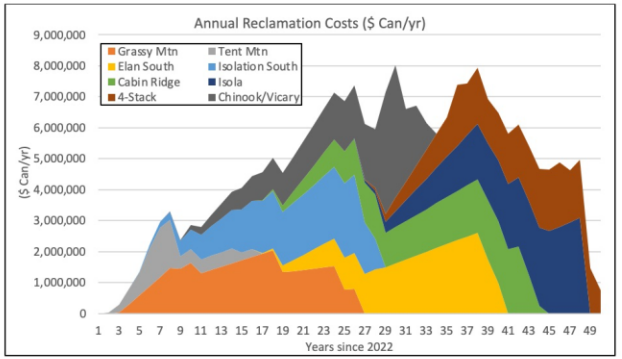


Figure 95. Annual (upper) and cumulative (lower) reclamtion costs ($) under the Medium Growth Scenario.



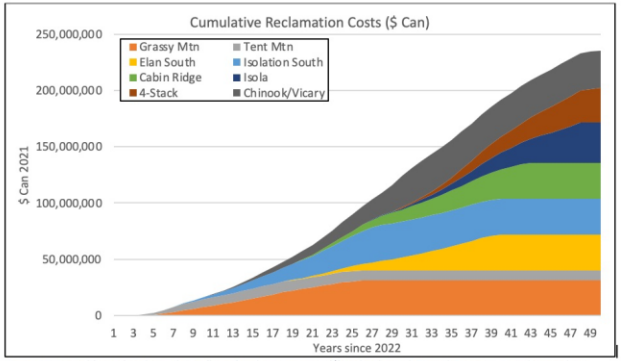
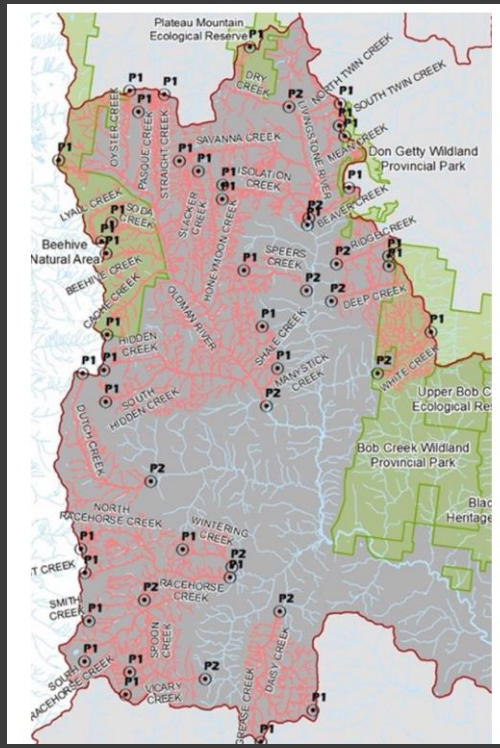


Figure 96. Annual (upper) and cumulative (lower) reclamation costs ($) under the High Growth Scenario. Based on medium reclamation cost estimate of $100,000/ha.

Westslope Cutthroat Trout



Livingstone Landowners Group

ALCES

Loss of Riparian Habitat

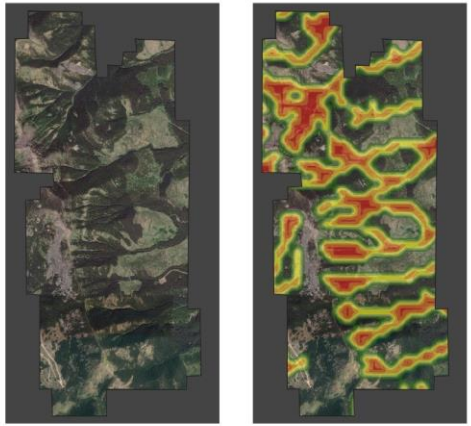


Figure 105. Isolation South prospective mine site showing the distribution of stream riparian buffers (50 m) from lotic features.

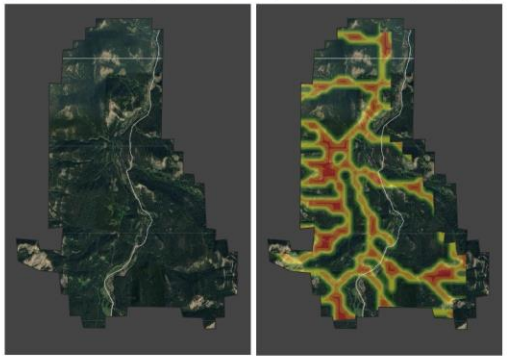


Figure 106. Elan South prospective mine site showing the distribution of stream riparian buffers (50 m) from lotic features.

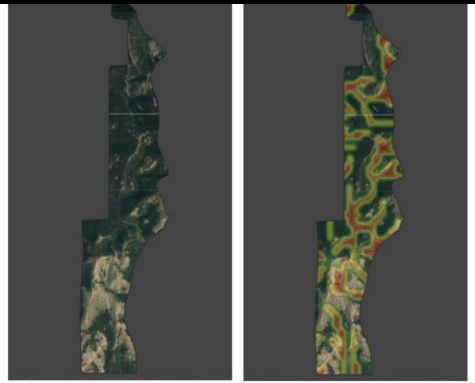


Figure 107. 4-Stack prospective mine site showing the distribution of stream riparian buffers (50 m) from lotic features.

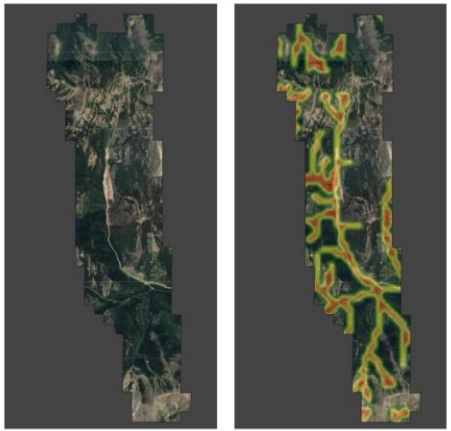


Figure 108. Chinook/Vicary prospective mine site showing distribution of stream riparian buffers (50 m) from lotic features.

Landscape Integrity

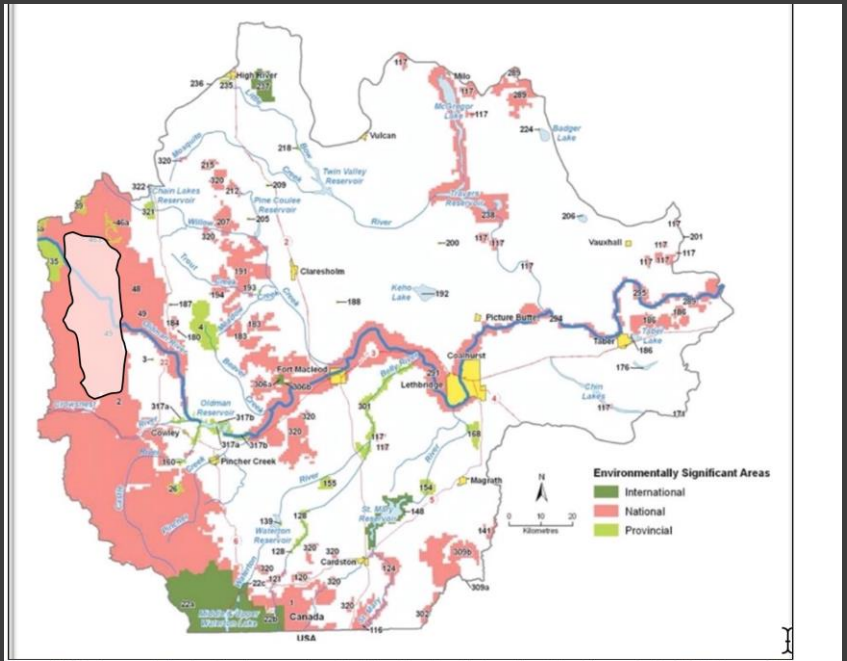
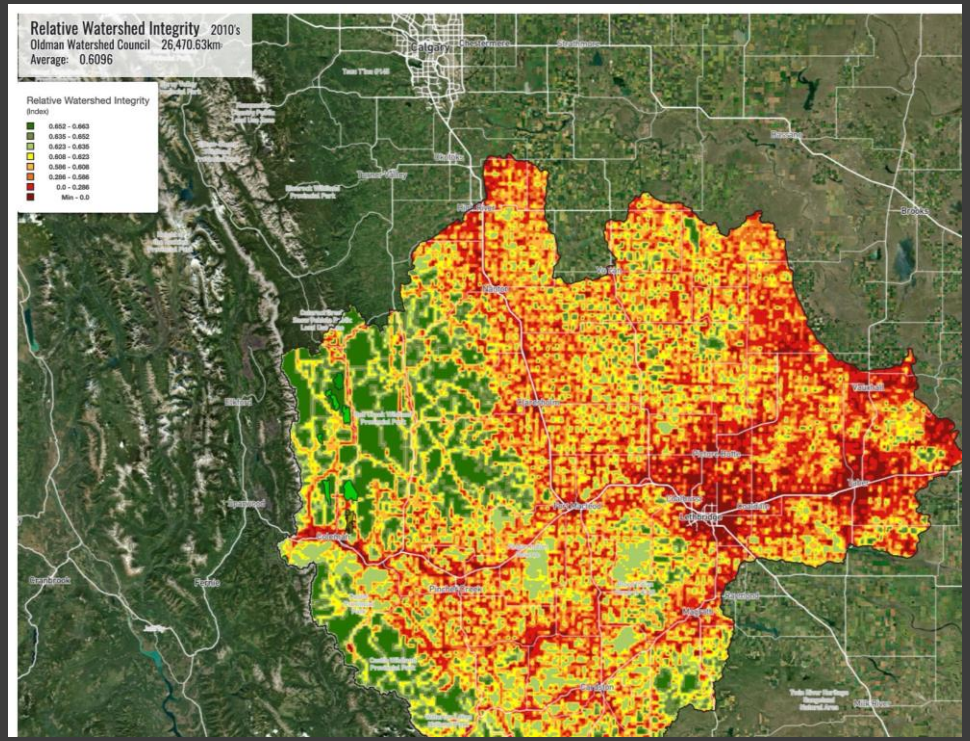


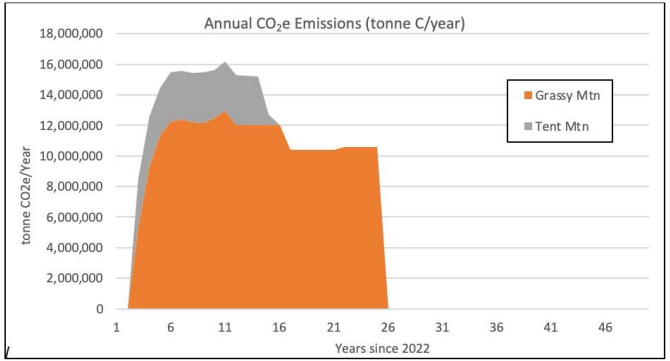
Figure 25. Environmentally significant areas of provincial, national and international significance in the ORW. Source: Oldman Watershed Council. The generalized distribution of existing coal leases in Category 2 north of the Crowsnest Pass is illustrated with black boundary and light white translucent shading. These coal leases occur in areas defined as "environmentally significant" at a National scale.



Livingstone Landowners Group

ALCES

CO_2e Emissions



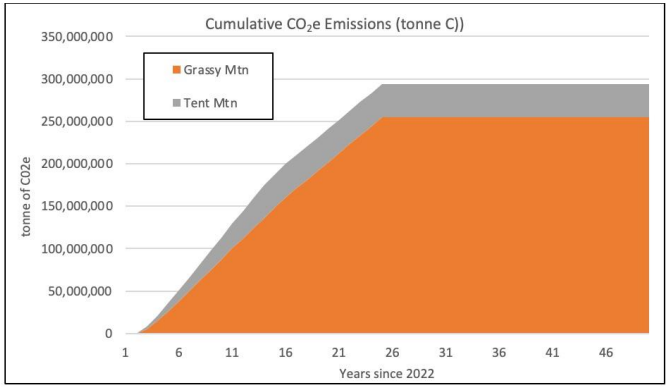
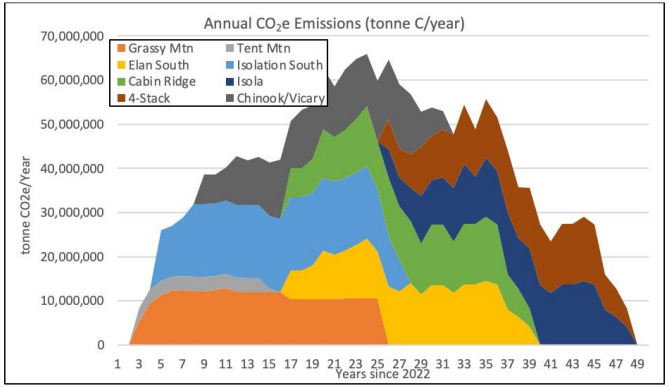


Figure 100. Annual (upper) and cumulative (lower) CO_2e emission (full life cycle) under the High Growth Scenario.



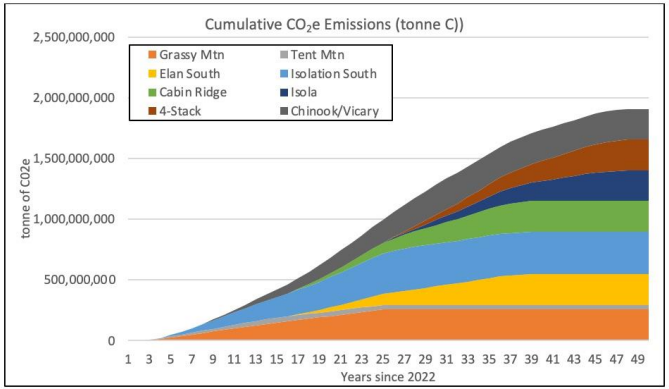


Figure 101. Annual (upper) and cumulative (lower) CO_2e emission (full life cycle) under the High Growth Scenario.

Summary

Current Values of Oldman Watershed Headwaters

- Critical for provision of water quality and quantity
- Provides important Landscape Connectivity at Local, Regional and International scales
- Refugia for remaining populations and habitat of endangered Westslope cutthroat trout
- One of the last landscapes supporting cow/calf operators on native fescue rangeland

Should Surface Coal Mining Proceed in the headwaters of the ORW

- Create challenges relating to selenium toxicity of water unless very high recovery rates (>90%) can be maintained over long temporal scales (decades to centuries). Jeopardize all downstream land uses.
- Although gross water demand from coal mining would be low at a basin scale, it would be high in the basin's headwaters, particularly in late summer and during winter
- Loss of water quantity, water quality (selenium), and loss of lotic and riparian habitat all represent risk to threatened Westslope Cutthroat Trout populations
- Loss of wilderness integrity and connectivity along the East Slopes
- Large multi-decadal mine reclamation liability (area and cost)
- Would injure Canada's ability to achieve its national and international commitments to GHS emissions